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Distinguished Lecture Series

WATER SPLITTING FROM SEA TO AIR

Presented by:

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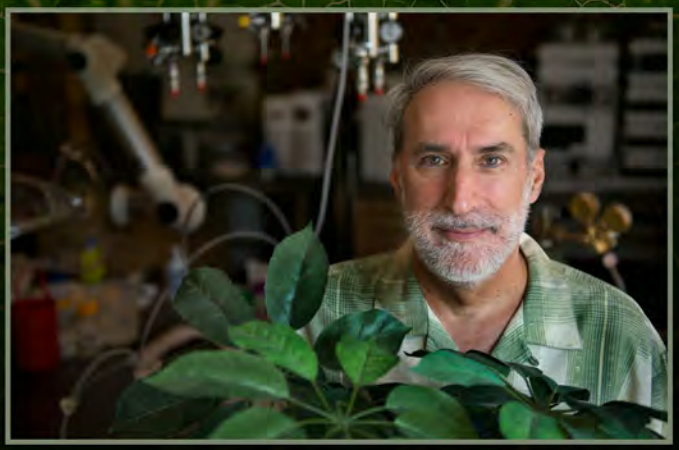
IN THE JUNKER CENTER



Office of Naval Research
875 N. Randolph St., Arlington, Virginia
Bobby Junker Executive Conference Center, 14th Floor

Water Splitting from Sea to Air

Catalysts have been invented that accomplish the solar fuels process of natural photosynthesis – the splitting of water to hydrogen and oxygen using sunlight – under ambient conditions. The catalysts are self-healing, permitting water splitting to be accomplished using any water source—which is critical development of: (1) the artificial leaf, as it allows for the facile interfacing of water splitting catalysis to materials such as silicon and (2) the bionic leaf, as it allows for the facile interfacing of water splitting catalysis to bioorganisms. For the latter, using the tools of synthetic biology, a bio-engineered bacterium has been developed to convert carbon dioxide from air, along with the hydrogen produced from the catalysts of the artificial leaf, into biomass and liquid fuels, thus closing an entire artificial photosynthetic cycle. The HBI, called the bionic leaf, operates at unprecedented solar-to-biomass (10.7%) and solar-to-liquid fuels (6.2%) yields, greatly exceeding the 1% yield of natural photosynthesis.

Extending this basic science, catalysts have been adapted to allow for the generation of breathable oxygen from seawater. Here oxygen must be produced selectively from seawater without producing other toxic contaminants, most notably chlorine and bromine. This selectivity has been achieved. Moreover, the hydrogen produced as a by product of water electrolysis may be combined with carbon dioxide to produce soluble salts (as opposed to fuels as described above), which may dissolve directly in seawater. In doing so, a closed loop cycle for generating and managing oxygen during diving operations may be achieved.

ABOUT
Daniel G Nocera, Ph.D.

Daniel G. Nocera is the Patterson Rockwood Professor of Energy at Harvard University. Widely recognized in the world as a leading researcher in renewable energy, he is the inventor of the artificial leaf (Time Innovation of the Year 2011) and bionic leaf (World Economic Forum Technology Breakthrough of the Year 2017). Together these discoveries accomplish a complete artificial photosynthetic cycle at an efficiency that is 10 times greater than natural photosynthesis. Complementing his interest in solar energy conversion, Nocera contributed to other areas of science. He has designed layered antiferromagnets to explore exotic states arising from highly correlated spins and he created the first quantum spin liquid from S = ½ spins on a kagomé lattice, a long-sought prize in condensed matter physics. His group has also broken new ground in chemosensor design by developing nanocrystal sensors for the metabolic profiling of tumors. This technique is now being used by clinicians to develop new cancer drug therapies. Afield from chemistry, Nocera invented the Molecular Tagging Velocimetry (MTV) technique to make simultaneous, multipoint velocity measurements of highly three–dimensional turbulent flows. MTV has been employed by the engineering community to solve long-standing and important problems that had previously escaped characterization.

Before joining Harvard, Nocera was the Henry Dreyfus Professor of Energy at MIT. He has mentored 160 Ph.D. graduate and postdoctoral students, 70 of which have assumed academic positions, published over 450 papers, given over 950 invited talks and 125 named lectureships. In 2008, Nocera founded Sun Catalytix, a company committed to developing energy storage for the wide-spread implementation of renewable energy. The assets of the flow battery were purchased by Lockheed Martin in August 2014, and flow battery is now being commercialized under the venture, Lockheed Martin GridStar™ Flow. The invention allows large grid scale storage, and thus has the benefit of accelerating the widespread adoption of renewable electricity. A second company, Kula Bio, was founded by Nocera in 2018. The company is focused on the development of renewable and distributed crop fertilization and land restoration.